1992

LAKE AND WETLAND MONITORING PROGRAM

REPORT/SUMMARY

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Summary

The Kansas Department of Health and Environment (KDHE) Lake and Wetland Monitoring Program surveyed the water quality conditions of 28 Kansas lakes during 1992. Nine of these lakes were federal reservoirs, two were major wetlands, and the remaining 17 represented State Fishing Lakes/State Parks, city/county lakes, small ponds within the Cimarron National Grasslands, or large private lakes that provide public recreation.

Most of the surveyed lakes appeared to be constant to increasing, over time, with regard to their assigned trophic state. Thirteen lakes indicated reasonably constant trophic states since their last surveys, while 11 indicated an increased trophic state. In general, the increases in lake trophic state indicated degrading water quality conditions, but may also have been influenced by recent drought conditions. Four lakes were surveyed in 1992 that indicated an improvement (decrease) in trophic state since their last water quality survey.

Only 20 exceedences of the Kansas numeric water quality criteria, or Environmental Protection Agency (EPA) water quality guidelines, were documented in the surface waters of the 28 surveyed lakes. Eleven of these exceedences concerned aquatic life support criteria. Nine concerned water supply, livestock watering, or irrigation criteria. Of the latter, only 4 exceedences occurred in lakes that actually hosted water supply, livestock watering, or irrigation uses.

Atrazine was the most often detected pesticide in Kansas lakes during 1992. Five lakes had detectable concentrations of atrazine within their main bodies. These detections ranged in concentration from 1.3 to 12.7 ug/L. Dual was detected in two lakes (concentration ranging from 1.9 to 3.4 ug/L), while alachlor was detected in one (0.88 ug/L). All five lakes with detectable atrazine levels exceeded available aquatic life support numeric criteria (EPA Criterion Continuous Concentration of 1.0 ug/L). Two of the five lakes, one of which supports drinking water supply use, exceeded the Environmental Protection Agency Maximum Contaminant Level (MCL) for atrazine (3.0 ug/L). Dual and alachlor detections did not exceed any of the published numeric criteria.

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INTRODUCTION

Development of the Lake and Wetland Monitoring Program

The Kansas Department of Health and Environment (KDHE) Lake and Wetland Monitoring Program was established in 1975 to fulfill the requirements of the 1972 Clean Water Act (Public Law 92-500) by providing Kansas with background water quality data for water supply and recreational impoundments, by determining regional and time trends for those impoundments, and by identifying pollution control needs within individual lake watersheds.

Program activities originally centered around a small sampling network comprised mostly of federal lakes, with sample stations at numerous locations within each lake. In 1985, the number of stations per lake were reduced to a single station within the main body of each impoundment. This, and the elimination of parameters with limited interpretive value, allowed expansion of the lake network to its present 130 sites scattered throughout all the major drainage basins and physiographic regions of Kansas.

In 1989, KDHE initiated a Taste and Odor/Algae Bloom Technical Assistance Program for public drinking water supply lakes. This was done to better aid water suppliers in identifying and controlling taste and odor problems related to lake processes and algal ecology.

Overview of the 1992 Monitoring Activities

Staff of the KDHE Lake and Wetland Monitoring Program visited 28 Kansas lakes during 1992. Of the 28 surveyed sites, eight were large federal lakes last sampled in 1988 and 1989, two were State Fishing Lakes (SFLs)/State Parks/Game Management Areas, eleven were city/county lakes (CLs), two were major wetland/wildlife areas (WMAs) in Kansas, one was a federal lake being sampled more frequently due to ongoing nonpoint source pollution control efforts (Hillsdale), one was a private lake open to public recreation (Lake LaCygne), and three were small lakes within the Cimarron National Grasslands in Morton County. Fifteen of the 28 lakes serve as public water supplies (PWSs). Three were new to the lake network. Table 1 compiles some general information on the lakes surveyed during 1992.

While man-made lakes are usually termed "reservoirs", this report shall use the term "lake" to define all bodies of standing water within the state.

Table 1. General Information Pertaining to Lakes Surveyed in 1992.

Lake	Basin	Authority	PWS(*)	Last Surveyed
Allen/Admire City Lake	MC	Local	*	1987
Anthony City Lake	LA	Local		1990
Big Hill Lake	VE	FMPR	*	1989
Bronson City Lake	MC	Local	*	1986
Elk City Lake	VE	FMPR	*	1989
Fall River Lake	VE	FMPR	*	1989
Fort Scott City Lake	MC	Local	*	1986
Garnett North Lake	MC	Local	*	1985
Harvey County West Lk.	LA	Local		1987
Hiawatha City Lake	MO	Local		1979
Hillsdale Lake	MC	FMPR	*	1990
Jamestown WMA	KR	State		1989
Kirwin Lake	SO	FMPR		1989
LaCygne Lake	MC	Private		1986
Lake Afton	LA	Local		1987
Lovewell Lake	KR	FMPR	*	1988
Moss Lake (central)	CI	Federal		new
Moss Lake (east)	CI	Federal		new
Moss Lake (west)	CI	Federal		new
Norton Lake	UR	FMPR	*	1989
Pleasanton Lake	MC	Local	*	1986
Richmond City Lake	MC	Local	*	1987
Shawnee Co. SFL	KR	State		1987
Texas Lake WMA	LA	State		1989
Toronto Lake	VE	FMPR	*	1989
Waconda Lake	SO	FMPR	*	1989
Wilson Co. SFL	VE	State		1987
Yates Center Lake	VE	Local	*	1991

CI = Cimarron
KR = Kansas/Lower Republican
LA = Lower Arkansas
MC = Marais des Cygnes
MO = Missouri
NE = Neosho
SO = Solomon
SS = Smoky Hill/Saline
UA = Upper Arkansas
UR = Upper Republican
VE = Verdigris
WA = Walnut

FMPR = Federal Multipurpose Reservoir

WMA = Wildlife/Game Management Area

In addition to routine lake monitoring, numerous private ponds were investigated as part of the Taste and Odor/Algae Bloom identification program within KDHE. The thrust of the program is to determine if in-lake processes or algal ecophysiology are the primary causes of a given taste and odor incident and to suggest possible corrective measures when applicable. The majority of the complaints and special projects during 1992 were associated with fishkills and/or odors and algae blooms within small private lakes.

METHODS

Yearly Selection of Monitored Sites

Since 1985, the 24 large federal lakes in Kansas have been arbitrarily partitioned into three groups of eight. Each group is sampled once during a three year period of rotation. Up to 22 smaller lakes are sampled each year in addition to that year's block of eight federal lakes. These smaller lakes are chosen each year for sampling based on three considerations: (1) Is there recent data available (within the last 3-4 years)?; (2) Is the lake showing indications of pollution that require enhanced monitoring?; or (3) Have there been water quality assessment requests from other administrative or regulatory agencies (state, local, or federal)?

Sampling Procedures

At each lake, a boat is anchored over the old stream channel near the dam. This point is station 1 for each lake, and should represent the area of maximum depth. Duplicate water samples are taken by Kemmerer sample bottle at 0.5 meters below the surface for determination of inorganic chemistry (basic anions and cations), algal community composition, chlorophyll-a, nutrients (ammonia, nitrate, and total phosphorus), and metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc). Duplicate water samples are also taken at 0.5 meters above the lake substrate for the determination of inorganic chemistry, nutrients, and metals. In addition, a single pesticide sample is taken at 0.5 meters and duplicate surface bacterial samples (fecal coliform and fecal streptococci) are taken at either the public swimming area or main boat ramp area.

Beginning in 1992, macrophyte surveys are conducted at each of the smaller lakes (<1,000 acres) within the KDHE Lake and Wetland Monitoring Program sampling network. The survey consists of the selection of 10-20 sampling points, scattered in a regular pattern over the lake surface. At each sampling point, the boat is stopped and a grappling hook cast to rake the bottom for submersed aquatic plants. This, combined with visual observations at each station, determines presence or absence of macrophytes at the station. If present, macrophyte species are identified and recorded on site. Those species that can't be identified in the field are placed in plastic bags, on ice, for identification at the KDHE Topeka office. Presence/absence data, and species specific presence/absence data, are used to calculate a "percent bottom cover" estimate for each lake.

At each lake, measurements are made at station 1 for temperature and dissolved oxygen profiles, pH, and Secchi disk depth. All samples are preserved and stored in the field in accordance with KDHE standard operating procedure (KDHE, 1985). Field measurements, chlorophyll analysis, and algal taxonomy are conducted by staff of KDHE's Office of Science and Support. All other analyses are carried out by the KDHE Health and Environmental Laboratory (KDHE, 1984).

Taste and Odor/Algae Bloom Program

In 1989, KDHE initiated a formal Taste and Odor/Algae Bloom Technical Assistance Program. Technical assistance concerning taste and odor incidences in water supply lakes, or algae blooms in lakes and ponds, may take on varied form. Investigations may simply involve identification of algal species present within a lake, or they may entail the measurement of numerous physical, chemical, or biological parameters including watershed land use analysis to identify nonpoint pollution sources. Investigations are generally initiated at the request of treatment plant personnel, local authorities, or personnel at any KDHE District Office. While lakes used as public water supplies are the primary focus, a wide variety of samples related to algal odors and fishkills, from both streams and lakes, are accepted for analysis.

RESULTS AND DISCUSSION

Lake Trophic State

Calculation of the Carlson Chlorophyll-a Trophic State Index (TSI) remains a useful tool for comparison of lakes in regard to general ecological functioning and level of productivity (Carlson, 1977). Table 2 presents TSI scores for the 1992 lakes, previous TSI scores for lakes with past data, and an indication of the extent that individual lakes were dominated by submersed and floating-leaved vascular plant communities (macrophytes). Since chlorophyll TSI scores are based on the planktonic algal community, a dominance by macrophytes "bumped" the trophic state classification to the next highest level than that assigned by TSI score alone. The system used to assign trophic state, based on the TSI score, is given below. It represents an in-house modification of the Carlson TSI system to account for macrophytic productivity. Trophic state classification is adjusted for macrophytes where percent areal cover is estimated at 30% or greater.

TSI score of 0-39 = Oligotrophic/Mesotrophic = O/M or,

O/M = A lake with a low level of planktonic algae, no large macrophyte community, and no overt turbidity problems.

TSI score of 40-49 = Mesotrophic = M or,

M = A lake with only a moderate planktonic algal community, or a small algal community combined with a large macrophyte community.

TSI score of 50-63 = Eutrophic = E or,

E = A lake with a large planktonic algal community or a moderate algal community combined with a large macrophyte community. This category is further divided as follows:

TSI = 50-54 = slightly eutrophic = SE
TSI = 55-59 = eutrophic
TSI = 60-63 = very eutrophic = VE.

TSI score of 64 or greater = Hypereutrophic = H or,

H = A lake with a very large planktonic algal community or a large algal community combined with a large macrophyte community.

All Carlson chlorophyll TSI scores are calculated by the following formula, where C is the phaeophytin corrected chlorophyll-a level in ug/L (Carlson, 1977):

$$TSI = 10(6-(2.04-0.68\ln(C))/\ln 2).$$

The composition of the algal community often gives a better ecological picture of a lake than relying solely on a trophic state classification. Table 3 presents both total algal cell count and percent composition of several major algal groups for the lakes surveyed in 1992. Lakes in Kansas that are nutrient enriched tend to be dominated by green or blue-green species, while those dominated by diatom communities may not be so enriched. Certain species of blue-green, diatom, or dinoflagellate algae may contribute to taste and odor problems, when present in large numbers, in lakes or streams that serve as public drinking water sources.

Table 2. Current and past TSI scores, and trophic state classifications for the 1992 lakes. The abbreviations used previously for trophic state levels (O/M, M, E, H) apply here. An asterisk appearing after the name of a lake denotes that the lake was macrophyte dominated. In such a case, the trophic state based solely on TSI score is given, followed by the macrophyte-adjusted TSI score in parentheses.

Lake	1992 TSI & Status		Previous Status
Allen/Admire Lake	58	E	E
Anthony Lake	na	-	H
Big Hill Lake	55	E	E
Bronson City Lake	61	VE	M
Elk City Lake	49	M	M
Fall River Lake	46	M	M
Fort Scott City Lake*	41	M(E)	H
Garnett North Lake	64	H	H
Harvey Co. West Lake	64	H	H
Hiawatha City Lake	70	H	Unknown
Hillsdale Lake	59	E	E
Jamestown WMA	51	SE	H
Kirwin Lake	68	H	E
LaCygne Lake	68	H	E
Lake Afton	59	E	H
Lovewell Lake	65	H	E
Moss Lake (central)	59	E	Unknown
Moss Lake (east)	47	M	Unknown
Moss Lake (west)*	38	O/M(E)	Unknown
Norton Lake	62	VE	E
Pleasanton Lake	56	E	E
Richmond City Lake*	59	E(H)	E
Shawnee Co. SFL*	52	SE(VE)	M
Texas Lake WMA	57	E	H
Toronto Lake	53	SE	M
Waconda Lake	59	E	M
Wilson Co. SFL	57	E	M
Yates Center Lake*	53	SE(VE)	E

Table 3. Algal communities present in the 1992 lakes at the time of sampling. The value in the count column is in cells/uL. "Other", in the far right column, refers to euglenoids, cryptophytes, dinoflagellates, and other single-celled flagellates. A "*" next to a number indicates that the percent of total, based on a biomass consideration, would be significantly above the percent of total shown, which is based on cell numbers.

Lake	Total Count (cells/uL)	Percent Composition			
		green	blue-green	diatoms	other
Allen/Admire Lake	14.5	94	0	2	4
Anthony City Lake	1.3	100	0	0	0
Big Hill Lake	47.4	8	92	0	0
Bronson City Lake	25.3	83	16	0	1
Elk City Lake	1.4	45	0	36	*18
Fall River Lake	2.8	44	0	*53	2
Fort Scott Lake	2.5	95	0	0	*5
Garnett North Lake	56.1	28	70	2	<1
Harvey Co. West L.	132.0	4	95	<1	<1
Hiawatha City Lake	5.8	20	16	*60	*4
Hillsdale Lake	11.5	*59	11	29	<1
Jamestown WMA	11.2	8	0	87	5
Kirwin Lake	90.9	4	94	2	<1
LaCygne Lake	131.7	17	79	4	0
Lake Afton	19.7	47	38	11	4
Lovewell Lake	15.5	48	30	*19	<3
Moss Lake (central)	29.9	43	42	*13	*2
Moss Lake (east)	26.8	*3	0	1	96
Moss Lake (west)	1.1	65	0	0	*36
Norton Lake	56.1	*20	74	*5	<1
Pleasanton Lake	5.0	57	0	33	10
Richmond City Lake	61.9	11	87	1	<1
Shawnee Co. SFL	6.5	0	0	93	7
Texas Lake WMA	13.0	92	0	4	*4
Toronto Lake	7.9	56	<6	34	<5
Waconda Lake	8.9	86	0	0	*14
Wilson Co. SFL	4.5	51	0	*39	*10
Yates Center Lake	4.7	30	65	1	4

Trends in Trophic State

Trends in trophic state, among these 28 lakes, appeared to be stable to degrading over time. Table 4 presents the results of the comparison of current trophic state to past records. Among the 13 lakes maintaining stable trophic states, four are identified as "tentatively stable" because little, or no, past data exists. These four lakes include the three "Moss Lakes" from the Cimarron National Grasslands, and Hiawatha City Lake.

Of the 28 lakes surveyed in 1992, 11 indicate a degrading condition, as evidenced by increases in lake trophic state. Among these, the three lakes in the Solomon and Upper Republican River Basins (Kirwin, Waconda, and Norton Lakes) have been affected by recent drought conditions, and the trophic state increases may not be reflective of longer term trends.

Only four lakes, out of the 28, have undergone any improvement in water quality as evidenced by decreasing lake trophic state. Of these four, two are wetlands that had trophic states artificially lowered by heavy rainfall and hydraulic flushing in the weeks prior to sampling.

Table 4. Trends over time for lake trophic state classification within each major river basin in Kansas.

	Number of Lakes		
Basin	Constant	Improving	Degrading
Cimarron	3?	-	-
Kansas/Lower Republican	-	1	2
Lower Arkansas	2	2	-
Marais des Cygnes	4	1	3
Missouri	1?	-	-
Solomon	-	-	2
Upper Republican	-	-	1
Verdigris	3	-	3
Totals	13	4	11

Three lakes (Richmond City Lake, Shawnee Co. SFL, and Yates Center Lake) were included within the "degrading" category due to the recent availability of macrophyte data. Table 5 presents data on macrophyte cover for 14 of the 28 lakes surveyed during 1992. Of the 14 lakes not surveyed, 12 were federal lakes, wetlands, or large private lakes which are not amenable to the macrophyte survey protocol. Two of the "Moss Lakes" in the Cimarron National Grasslands were not included in the macrophyte survey, owing to lack of boating access.

Table 5. Macrophyte community structure in 14 of the lakes surveyed during 1992. Macrophyte community in these surveys refers to submersed and floating-leaved aquatic plants, but not to the emergent shoreline community. The percent cover following percent total cover is the cover estimate for each detected species (Note: due to overlap in species cover, the percentages under community composition may not equal the percent total cover.).

Lake	% Total Cover	Community Composition	
Allen/Admire Lake	0%	0%	none present
Anthony Lake	0%	0%	none present
Bronson City Lake	8%	8%	Najas guadalupensis
Fort Scott City Lake	35%	25%	Chara zeylanica,
		5%	Potamogeton nodosus, and
		5%	Najas guadalupensis
Garnett North Lake	0%	0%	none present
Harvey Co. West Lake	0%	0%	none present
Hiawatha City Lake	0%	0%	none present
Lake Afton	0%	0%	none present
Moss Lake West	100%	100%	Chara canescens, and
		<10%	Potamogeton pectinatus
Pleasanton Lake	0%	0%	none present
Richmond City Lake	30%	30%	Najas guadalupensis,
		10%	Chara zeylanica, and
		10%	Potamogeton pusillus
Shawnee Co. SFL	80%	80%	Potamogeton nodosus,
		35%	Potamogeton pectinatus,
		25%	Nitella flexilis, and
		15%	Najas guadalupensis
Wilson Co. SFL	0%	0%	none present
Yates Center Lake	47%	47%	Najas guadalupensis,
		6%	Potamogeton pectinatus, and
		41%	Potamogeton pusillus

As can bee seen in Table 5, nine of the 14 macrophyte surveys resulted in no macrophytes being found. This may mean that cover was non-existent, or it may merely indicate that macrophyte presence was so sparse as to preclude detection using our current technique. Of the six lakes with macrophyte communities, the common plant species were various forms of pondweed (Potamogeton spp.), water naiad (Najas sp.), and stonewort algae (Chara and Nitella spp.).

Contact Recreation and Fecal Coliform Bacterial Counts

Beginning with the 1992 lake surveys, the Lake and Wetland Monitoring Program discontinued collecting bacterial samples from the open waters of network lakes. Past data indicates strongly that fecal coliform counts are very low in the open water of Kansas lakes. This condition is likely due to predation by protozoan organisms and the fact that limnetic environments are hostile to the survival of gut bacteria in general. In preference to open water samples, fecal bacteria counts are now made from either the main swimming beach (if a swimming beach exists) or the main boat ramp area (if there is no swimming beach). The selection of the boat ramp area as an alternate sampling site was made since it is one of the most likely sites for contact recreation, whether or not facilities exist for swimming.

Table 6 presents the bacterial data collected during the 1992 sampling season. All counts are compared to the 200 colonies/100 mL standard for contact recreation within the Kansas Surface Water Quality Standards (KDHE, 1987). Out of the 28 sites, ten have swimming beaches. Out of these ten sites, only two had counts exceeding 200 colonies/100mL.

Limiting Nutrients and Physical Parameters

The determination of which nutrient, or physical characteristic, "limits" phytoplankton production is of primary importance in lake management. If certain features can be identified, which exert exceptional influence on lake water quality, those features can be addressed in lake protection plans to a greater degree than less important factors. In this way, lake management can be made more efficient.

The concept of limiting nutrients, or limiting factors, is often difficult for the layman to grasp. The following analogy is provided to attempt clarification of the concept:

> A person is given 10 spoons, 9 knives, and 5 forks. They are then asked to place sets of utensils at each place at a table. Further, only complete sets of utensils are to be placed, with a complete set including all three tools. The question is, "What tool is the limiting factor?"
>
> In this example, the number of forks available "limits" the number of place settings that can be made. Therefore, forks become the limiting factor for this scenario.

In a lake ecosystem, the level of algal production is the "place setting," while plant nutrients and light availability are the "spoons, forks, etc." Common factors that limit algal production in lakes are the levels of available nutrients (primarily phosphorus and nitrogen) and the amount of light available to

Table 6. Fecal coliform bacterial counts from the 28 lakes and wetlands surveyed during 1992. Since wetlands and lakes without facilities for contact recreation are not designated for contact recreation use (KDHE, 1987), those values are given for informational purposes only. It should also be kept in mind that these are one time grab samples taken during the week, not during the weekends which should be higher use periods. All units are in "number of colonies per 100 mL of lake water."

Lake	Site Location	Fecal Coliform Count
Allen/Admire Lake	none	na
Anthony City Lake	swim beach	<100
Big Hill Lake	swim beach	730
Bronson City Lake	boat ramp	460
Elk City Lake	swim beach	70
Fall River Lake	boat ramp	17
Fort Scott City Lake	swim beach	205
Garnett North Lake	boat ramp	<10
Harvey Co. West Lake	swim beach	125
Hiawatha City Lake	boat ramp	360
Hillsdale Lake	swim beach	<10
Jamestown WMA	shoreline	125
Kirwin Lake	boat ramp	<10
LaCygne Lake	boat ramp	<2
Lake Afton	swim beach	15
Lovewell Lake	swim beach	22
Moss Lake (central)	shoreline	85
Moss Lake (east)	shoreline	70
Moss Lake (west)	shoreline	140
Norton Lake	boat ramp	390
Pleasanton Lake	swim beach	31
Richmond City Lake	boat ramp	40
Shawnee Co. SFL	boat ramp	90
Texas Lake WMA	shoreline	50
Toronto Lake	boat ramp	10
Waconda Lake	swim beach	10
Wilson Co. SFL	boat ramp	<10
Yates Center Lake	boat ramp	20

power photosynthesis. Less common limiting factors in lakes include available levels of carbon, iron, manganese, temperature, and vitamins. These factors are seldom limiting in the surface waters of Kansas.

The use of nutrient ratios are commonly employed to estimate which major plant nutrients are limiting factors in lakes. These ratios take into account the relative needs of algae cells for the different chemical nutrients. Typically, total nitrogen/total phosphorus (TN/TP) mass ratios that are above 7.5 indicate phosphorus limitation. Conversely, TN/TP ratios below 7.5 indicate nitrogen limitation. Ratio numbers near 7.5 indicate that both, or neither, of these major plant nutrients may be limiting to phytoplankton production (Wetzel, 1983). The 1992 season marked the first during which total nitrogen data was available to the Lake and Wetland Monitoring Program, thus making the determination of limiting nutrients possible.

Table 7 presents limiting factor determinations for the lakes surveyed during 1992. It should be kept in mind that these determinations reflect the time of sampling and may not apply to other times of the year. Also, the assumption was made that no unusual circumstances were present at the time of sampling which would influence which nutrient or factor became the limiting one.

Table 7. Limiting factor determinations for the 28 surveyed lakes in 1992, including TN/TP ratios. The listing of the limiting factors is in the descending order of importance.

Lake	TN/TP Ratio	Limiting Factors Present
Allen/Admire Lake	33.8-38.2	phosphorus
Anthony City Lake	5.4-6.5	nitrogen, light
Big Hill Lake	>5.6	nitrogen?
Bronson City Lake	4.2-5.4	nitrogen
Elk City Lake	3.6	light, nitrogen
Fall River Lake	7.2-7.8	light, phosphorus, nitrogen
Fort Scott City Lake	>8.1	phosphorus
Garnett North Lake	>10.5	phosphorus
Harvey Co. West Lake	6.4	nitrogen, phosphorus, light
Hiawatha City Lake	13.4	phosphorus
Hillsdale Lake	>15.6	phosphorus
Jamestown WMA	5.4	nitrogen
Kirwin Lake	10.9-12.9	phosphorus
LaCygne Lake	>2.1	unknown
Lake Afton	<1.2	nitrogen
Lovewell Lake	9.0-12.6	phosphorus
Moss Lake (central)	14.0-19.0	phosphorus
Moss Lake (east)	>4.4	unknown
Moss Lake (west)	>10.7	phosphorus
Norton Lake	8.7-12.1	phosphorus
Pleasanton Lake	>1.8	unknown
Richmond City Lake	>1.0	unknown
Shawnee Co. SFL	>2.9	unknown
Texas Lake WMA	5.7-9.5	phosphorus, nitrogen
Toronto Lake	6.7-7.2	light, phosphorus, nitrogen
Waconda Lake	>19.4	phosphorus
Wilson Co. SFL	4.2-8.6	phosphorus, nitrogen
Yates Center Lake	>15.4	phosphorus

As can be seen from the data in Table 7, phosphorus (or phosphorus in combination with light availability) is the primary limiting factor for lakes surveyed during the summer of 1992. Twelve of the 28 lakes were primarily phosphorus limited, or limited by both phosphorus and light availability. Six lakes were limited primarily by nitrogen, or nitrogen combined with light availability. Another 5 lakes were limited by a combination of factors. Five lakes were counted as unknown due to difficulties in calculating TN/TP ratios, primarily due to phosphorus detection limits.

In Kansas, many lakes are influenced by the amount of light able to penetrate into the lake to power photosynthesis. In addition, this physical factor can change suddenly with storm water inflows or wind. However, despite its possibly intermittent influence, light limitation remains an important feature in the ecology of many lakes. During 1992, three lakes were viewed as primarily light limited, with two more secondarily limited by light availability. These lakes were located in south-central and southeast Kansas, where high turbidity in lakes is a common occurrence.

<u>Surface Water Exceedences of State Water Quality Criteria</u>

All numeric water quality criteria referred to in this section are taken from Chapter 28 of the Kansas Administrative Regulations (K.A.R. 28-16-28b through K.A.R. 28-16-28f), effective May 1, 1987, or from EPA water quality criteria guidance documents (EPA 1972, 1976; KDHE, 1987). Copies of the Standards may be obtained from the Office of Science and Support, KDHE, Building 740, Forbes Field, Topeka, Kansas 66620.

Under the category of chronic aquatic life support, a total of 9 exceedences of existing numeric criteria were documented during 1992. These occurred for five different metals, with copper being the parameter exceeded most often (63%). There were a total of two exceedences of existing numeric criteria under the category of acute aquatic life support during 1992. Both of the acute exceedences were for copper. Table 8 presents these exceedences for aquatic life support use.

Under the categories of water supply, irrigation, and livestock water, a total of 9 exceedences of existing water quality numeric criteria and/or EPA guidelines were documented during 1992 (Table 9). Out of these 9, 4 occurred in lakes that currently are serving those specific uses. Therefore, 56% of these reported exceedences are for informational purposes only and do not represent any impairment of existing uses. All 9 documented exceedences were under the drinking water supply category. The majority of exceedences under water supply were for iron and manganese (56% and 33% of the total, respectively), while a single exceedence for ammonia was documented (11% of the total).

Table 8. Chemical parameters exceeding chronic and acute aquatic life support criteria in lakes surveyed during 1992. Chemical symbols are from the Periodic Table of the Elements. Aquatic life support is abbreviated ALS. Only those seven lakes with some type of documented exceedence are included in the Tables 8 and 9.

	Chronic ALS					Acute ALS
Lake	Cu	Pb	Cd	Ag	Hg	Cu
Hiawatha City Lake	x					
Kirwin Lake		x	x			
Lovewell Lake	x					x
Norton Lake						
Shawnee Co. SFL	x				x	
Waconda Lake	x			x		
Wilson Co. SFL	x					x

Table 9. Exceedences of human use criteria and/or EPA guidelines within the surface waters of the lakes surveyed during 1992. Symbols are taken from the Periodic Table of the Elements. Only lakes with documented exceedences are included within the table. During 1992, there were no documented exceedences under the livestock watering or irrigation use categories. An "x" indicates that the exceedence occurred in a lake where water supply use exists at present. An "*" indicates that the exceedence occurred at a lake where water supply is not a current use.

	Water Supply Use		
Lake	Fe	Mn	Ammonia
Hiawatha City Lake	*	*	
Kirwin Lake	*	*	
Lovewell Lake	x		
Norton Lake	x	x	x
Shawnee Co. SFL			
Waconda Lake			
Wilson Co. SFL	*		

<u>Pesticides in Kansas Lakes, 1992</u>

Six lakes had detectable levels of pesticides within the main body of the lake during 1992. Table 10 lists these lakes and the pesticides that were detected, along with the level detected and analytical quantification limit. Three different pesticides were detected in total.

Atrazine continues to be the most often detected pesticide in lakes in Kansas (KDHE, 1991). Atrazine was identified in five of the six lakes with detectable pesticides. Two lakes had detections of Dual (metolachlor), and one lake had a detection of alachlor.

In all cases, the detection of these pesticides indicates impacts from agricultural nonpoint source pollution. The sites of most concern during 1992 were Allen/Admire City Lake and the Jamestown WMA wetland.

Table 10. Pesticides detected during 1992 in Kansas lakes. All values are in ug/L. Analytical quantification limits (in ug/L), and abbreviations, are as follows for the three detected pesticides: atrazine = 1.2, dual = 0.25, alachlor = 0.25. The "exceeded" column refers to whether the detection of atrazine exceeded current EPA aquatic life support (ALS) levels (1.0 ug/L), or whether the detection exceeded the current MCL of 3.0 ug/L for water supply (WS).

Lake	Pesticide			Exceeded	
	Atrazine	Dual	Alachlor	ALS	WS
Allen/Admire Lake	11.0	-	-	x	x
Hiawatha City Lake	-	3.40	-		
Hillsdale Lake	2.2	-	-	x	
Jamestown WMA	12.7	1.90	0.88	x	x
Richmond City Lake	1.9	-	-	x	
Waconda Lake	1.3	-	-	x	

Discussion of Nonpoint Sources of Pollution for Selected Lakes

Only one lake was selected, out of the 28, for individual discussion of nonpoint sources of pollution. It was felt that this lake merited individual attention based on the number and type of observed Water Quality Standard exceedences. The criteria for selecting lakes for further discussion were as follows. From Table 8, a lake was selected if more than three parameters exceeded an aquatic life support criterion, or more than one acute aquatic life support criterion was exceeded. From Table 9, a lake was selected if more than one parameter exceeded a "human use" water quality criterion, or if more than one use category had an exceedence. For the purpose of this discussion, only use exceedences in lakes that hosted those particular uses were considered.

The one lake surveyed during 1992 meriting further discussion was Norton Lake, in northwest Kansas. This larger (approximately 750 acre or 304 hectare) federal lake had exceedences under the drinking water supply category for iron, manganese, and ammonia. This lake has been plagued for many years with low water levels due to insufficient stream flows and recent drought conditions. During 1992, Norton Lake remained about 50 feet below normal pool level. As such, the lake has acted as a huge distilling basin, with elevated concentrations of many metals within its waters. Only the high level of total water hardness prevents a number of aquatic life support criteria for metals from being exceeded on a routine basis. Given the past and current hydrology, the exceedences in Norton Lake are likely attributable to natural causes, rather than human activity.

Taste and Odor/Algae Bloom Investigations and Other Special Investigations in 1992

From October 15, 1991 to October 15, 1992, KDHE conducted two special lake investigations and 16 investigations involving algae blooms and/or fishkills. This section serves to summarize the activities of the Taste & Odor/Algae Bloom Technical Assistance Program and the Kansas Clean Lakes Program for 1992.

On June 10, 1992, a brief study of Vaquero Lake (Shawnee Co.) was concluded. Residents had indicated that filamentous mats of algae were a common summer problem. Watershed modeling was conducted using EUTROMOD 2.4 to determine what nutrient loads could be expected, and to provide an estimate of expected lake condition based on current watershed land uses. It was concluded that, given the small watershed which is rich in cropland and urban area, Vaquero Lake should normally be extremely productive. With so little watershed area to work with, it was also concluded that little positive impact would be achieved by pursuing watershed pollution control, short of buying all the cropland and converting it to native grass. Septic system impact was estimated at 8-9% of the total nutrient load to the lake. Symptomatic treatment of the algal mats was suggested as the only economically feasible avenue to pursue, combined with septic system maintenance and urban best management practices.

On October 9, 1992, a study was completed at a private impoundment on Little Chicken Creek (Douglas Co.). Residents above the lake had complained about recent odors from the lake and were concerned that a feedlot facility above the lake was the cause. Again, watershed modeling with EUTROMOD 2.4 was employed to estimate average nutrient loads from the various watershed land uses, and estimate the average in-lake water quality conditions. The results of the modeling suggested that the lake should be of a fairly high trophic state on average. Lake morphometry also suggested that the lake should stratify early each year, with the likelihood of hypolimnetic anoxia being high. Given that the lake surface discharge was high in ammonia (3.5 mg/L) and low in dissolved oxygen (2.1 mg/L), and that the complaint occurred in late summer after a period of rain and wind, it was concluded that normal lake turn-over was the cause of the problem. Alternate modeling runs, which removed all feedlot inputs, indicated that while feedlot areas contribute 10-18% of the total nutrient load, they only contribute to 1-3% of the in-lake water quality condition (as indicated by total nutrients, algal biomass, water clarity). This is due to the already high trophic state expected from such a lake/watershed system.

On October 30, 1991, a fishkill was reported on Eight Mile Creek near Douglass, in southwest Butler County. Examination of the submitted algae sample indicated a small (5,000 cells/mL) community of mixed green algae, diatoms, and cryptophytes. There was no indication of an algae bloom being contributory to the fishkill.

On January 6, 1992, an algae sample was submitted by the City of El Dorado due to taste and odor problems in the community drinking water derived from El Dorado Lake (Butler Co.). Examination of the water sample indicated a very small (300 cells/mL) community of colonial green algae. It was suggested that actinomycete fungi might be responsible for causing the taste and odor problems, since the primary complaint was a reported musty or earthy odor (Mallevialle and Suffet, 1987). City water treatment personnel were contacted and they indicated that even though activated carbon was being added early in the process stream, the problem had continued unabated. It was suggested that the city delay the addition of the activated carbon to just before final disinfection. Once city staff implemented this change, no more complaints were received.

On April 17, 1992, two sets of algae samples were submitted from the KDHE South-Central District Office (SCDO) from the Teal Brook Estates housing development in Wichita (2 ponds), and from the Wellington Airport wastewater treatment lagoon. The airport lagoon contained a large community (115,000 cells/mL) of colonial green algae and dinoflagellates. It was not clearly indicated what the initial complaint concerned, but the algae community was not particularly unusual for a lagoon system in early spring. The Teal Brook Estates sample was from two ponds, in series, in a housing development. Pond #1 had a large (40,000 cells/mL) community composed mainly of diatoms and a few blue-green algae. Pond #2 contained a very dense filamentous green algae community. The complaint had apparently involved what appeared to be recurrent blue-green algae blooms, but the sampling date may have missed the peak concentration of algae. Fishkill and odor problems apparently accompanied the bloom.

On May 20, 1992, an algae sample was submitted by the SCDO from Lake Waltanna (Goddard, Kansas). The initial complaint from lake residents, concerned unpleasant odors from the lake. The sample contained about 140,000 cells/mL of what appeared to be rod-shaped bacteria, and the in-lake dissolved oxygen was <1 mg/L at the surface. The cause of the problem was eventually attributed to failing septic systems around the lake, possibly combined with the use of aquazine herbicide (a commercial aquatic herbicide containing simazine as the active ingredient) to treat algae mats during the month prior to the complaint.

On June 4, 1992, samples from two fishkill sites were submitted by the SCDO. The two sites were a one acre pond east of Wichita, near Petroleum Management Inc., and a 40 acre sand pit north of Wichita at Miles Sand Inc. The pond east of Wichita exhibited septic odors and very low oxygen. The algal community contained a small-moderate sized population of very small flagellates. It was not thought that the algae community was contributory to the fishkill. At the sand pit north of Wichita, the algae community consisted of a small number of the blue-green algae Oscillatoria sp. While tenuous, it was indicated that there may have been extensive bottom mats of this algae which could have been contributory to the fishkill. It was recommended that a search for such bottom mats be made, provided a more probable cause of the fishkill was not found.

On June 24, 1992, algae samples from the Romac Fishing Club Lake (Maize, Kansas) were submitted by the SCDO. A fishkill had recently occurred within the lake. The sample contained a small, mixed community of algae types, but no real indications of the probable cause of the fishkill. SCDO staff relayed that, prior to the kill, extensive mats of filamentous algae had been present at the surface. It was concluded that either the mats had been treated, or died off naturally, and caused rapid oxygen depletion.

On June 26, 1992, algae samples were submitted by the SCDO in response to a fishkill at Fox Pond (Colwich, Kansas). The two samples contained between 50,000 and 95,000 cells/mL of mixed diatoms. The samples also contained abundant decomposing vegetable matter. It was indicated that such a large diatom community is not typical of small Kansas ponds in the summer, and it appeared that some disruption of the normal pond ecology had occurred. What that disruption may have been was not determined, but the algae community in the samples was not a likely direct cause of the fishkill.

On July 2, 1992, algae samples from a fishkill at the Lucas Pond (Mulvane, Kansas) and from a citizen complaint at Teal Brook Estates were submitted by SCDO staff. The Lucas Pond sample contained a large amount of organic debris and a population of 15,000 cells/mL of euglenoid algae. The pond had a dissolved oxygen concentration of <1 mg/L and a brownish color. The color may have been due to the algae or dissolved organic matter, while the low dissolved oxygen was certainly due to the presence of decomposing organic matter. A severe hail storm (6-8 inches of hail total) preceded the fishkill, which could have chopped up enough local vegetation to overload the pond. While somewhat speculative, the hailstorm incident provides an illuminating anecdote about the diverse causes of fishkills and the conditions encountered during fishkill investigations.

The Teal Brook Estates sample contained a very large population of filamentous blue-green algae (Nostoc sp. and/or Anabaena sp.). The cell count was estimated to be in the millions to tens-of-millions of cells/mL. While many blue-green algae can, and do, produce toxins, KDHE does not have the facilities to determine toxicity of algae blooms. Therefore, the citizen was advised to assume the bloom was toxic, and to keep children and pets away from the water. It was reported that odors were very apparent, and anecdotal reports indicated some residents may have begun suffering from flu-like symptoms during the bloom (via aerosols from the pond surface). Efforts were made to work with the Teal Brook Estates Home Owners Association to produce a watershed/lake management plan. The citizen who had initially complained about the bloom brought the KDHE offer of technical assistance up at a regular Association meeting. The offer was rejected on the assertion that the membership did not feel there were any problems warranting changes in the housing development.

On July 10, 1992, the SCDO submitted an algae sample from a fishkill at the Lakepoint Housing Development in east Wichita. Present was a moderately large population (39,000 cells/mL) of small dinoflagellates and small euglenoid algae. It was assumed that these algae were the cause of the "tea coloration" of the pond, but not the primary cause of the fishkill. Dissolved oxygen in the pond was <2 mg/L. Whether the algae community was secondarily contributory to the fishkill was not determined.

On July 24, 1992, SCDO submitted algae samples from a fishkill at the Darrell Rau Pond near Wichita. This 3 acre, private pond had experienced extensive growths of submersed aquatic plants (likely Najas guadalupensis) previous to the fishkill. Within three weeks the plants were gone, dissolved oxygen was about 1 mg/L, and a fishkill had occurred. At first it was suspected that the macrophytes had been treated, with the result being rapid die-off and oxygen depletion. However, the fishkill had included both channel catfish and grass carp. Grass carp are commonly used to control submersed aquatic plants in small ponds. Initially, it was hypothesized that this might be the first documented case of a grass carp induced fishkill, due to the addition of the herbivorous fish into a weed choked pond, with subsequent plant destruction and de-oxygenation. The hypothesis was not supported when it was learned that the grass carp had been added 2 to 2.5 years previous to the fishkill. Why the fish did not provide control of the plants during early summer of 1992 has not been determined.

On August 3, 1992, SCDO submitted samples from Harvey County Sewer District #1 and from a duck kill that occurred along Cow Creek and the Deer Trail Housing Development in Wichita. The algae sample from Harvey County Sewer District #1 contained a very large (>1,000,000 cells/mL) community of mixed blue-green algae. In addition, there was abundant filamentous bacteria and protozoa present in the sample. The dominant alga, <u>Microcystis aeruginosa</u>, is capable of producing odors that are very similar to the odor of raw petroleum.

The samples from the Deer Trail duck kill contained a small population (4,000-5,000 cells/mL) of euglenoid algae. While this was probably not the cause of the kill, it was indicative of an organically enriched environment, which may have promoted conditions conducive to the duck kill.

On September 3, 1992, SCDO submitted algae samples from Cheney Reservoir (Reno, County). The samples were collected due to numerous taste and odor complaints being reported for drinking water in the Wichita area. The algae samples indicated the presence of a very large bloom (940,000 to 1,160,000 cells/mL) of the colonial blue-green alga <u>Microcystis aeruginosa</u>. It was indicated to both SCDO and Wichita water treatment plant staff that this alga is a common producer of odor complaints and toxic blooms worldwide. Literature concerning the toxic effects of this organism on livestock were passed along in case any livestock or wildlife kills were reported. Wichita water treatment plant staff also indicated that they were adding oxidant to the raw water, prior to treatment, in an attempt to remove the taste and odor compounds. It was indicated that such practices, applied early in the water treatment process, are rarely successful. In fact, they can lyse the algal cells, promoting greater release of toxins, and/or the oxidants can produce secondary taste and odor causing compounds to form. It was recommended that the city cease adding chemicals to the raw water and attempt to use activated carbon prior to the final disinfection step in the water treatment process.

<u>Conclusions</u>

The following conclusions are offered, based upon the lake monitoring data obtained during 1992.

1. Trophic state conditions suggested that most lakes surveyed in 1992 were either maintaining past levels of water quality or experiencing degradation of water quality. Only a small percentage had trophic state conditions that indicated an improvement over past levels.

2. Only one lake had sufficient numbers of surface water quality criteria exceedences to be discussed in more detail within the report. This one lake was thought to be impacted by natural hydrologic conditions.

3. Six of the 28 surveyed lakes had detectable concentrations of agricultural pesticides during the summer of 1992. Atrazine was the most commonly encountered pesticide. Most of these lakes were within the Missouri, Kansas, and Marais des Cygnes river basins of eastern Kansas.

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LAKE DATA AVAILABILITY

Lake data are available for all lakes included in the Kansas Lake and Wetland Monitoring Program. Water quality data may be requested by writing to the Office of Science and Support, KDHE, Building 740, Forbes Field, Topeka, Kansas 66620-0001. All data referenced within this report are accessible on STORET.